Flexible ICs: The technology evolves

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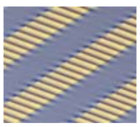
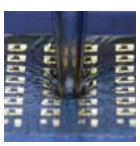
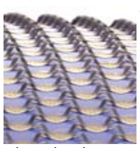


University of Illinois researchers first demonstrated a kind of elastic silicon in which thin ribbons of the material were directly attached to polydimethylsiloxane (PDMS) while it was being stretched. Once allowed to relax, the incorporated ribbons formed sine waves that varied in wavelength and amplitude when the elastic material was subsequently deformed. With this system, stretch and compression of a few percent each could be accommodated. The ribbons shown here are 20-µm wide and 100-nm thick.

However, researchers found they could get a more predictable ribbon shape, and more flexibility, by patterning the adhesive on the elastic substrate so the semiconductor ribbons could buckle without constraint by the PDMS. This produced patterns with freestanding sine waves and a greater ability to stretch and compress. The ribbons shown here, 50-µm wide and 290-nm thick, were deposited on a substrate with an initial strain of 50 percent. Using these techniques, the team achieved stretchability of 100 percent and compressibility of 25 percent.



Next, the researchers demonstrated that the technique could be used with working devices. Ultrathin circuits were fabricated on a sacrificial layer and then removed using chemical etching, as shown here. They were subsequently transferred to the stretched PDMS with the thin interconnects between circuits free to buckle to accommodate deformation of the substrate. The performance of the circuitry, encapsulated with polyimide for protection, was found largely unaffected by imposed strains within design limits.



To demonstrate that the technology could be used in a real-world application, the team built a hemispherical detector array, or electronic eye, using circuits like those shown here. To achieve the curvature, the team took a hemisphere of PDMS and stretched it radially to produce a flat membrane, like a drumhead. The circuits were transferred onto this substrate, then deformed with it as it relaxed to its normal shape. Finally, they were transferred onto its permanent substrate: an inverted hemisphere on a glass lens.

Researchers are now working to develop real applications, particularly biomedical and bio-inspired sensors. They will have to address issues of device density, ensuring that the thermal properties of the elastic substrates used do not impede the performance of the final systems, and bio-compatibility.

ELASTIC substrate-mounted silicon circuits can conform to objects with a relatively small radii of curvature--in this case, 2mm.

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